Coercivity is an essential property characterizing hard magnetic materials. The coercive fields and the magnetization reversal processes depend on not only the chemical compositions but also the microstructures of magnetic materials. Hence, to achieve high coercivity in magnetic materials, besides the concerns on the chemical compositions, the microstructural tailoring is a crucial issue. The formation of defected microstructures may bring about two major effects on the coercivity developments; one is related to the strain effects by introducing the stress-induced anisotropy and the other is related to the effects of defects on the reversal magnetization processes of magnetic materials.

In this work, mechanical milling was employed as an effective way to build up a high-level residual strain and high-density defects in cobalt ferrite (CoFe$_2$O$_4$) powdered materials. A high coercivity of up to 5.1 kOe was achieved after mechanical milling for a relatively short time. Based on x-ray diffraction and high-resolution transmission electron microscopy analysis, we presented a detailed study on the microstructure evolution during mechanical milling and their effects on the coercivity acquisition of cobalt ferrite materials. High coercivity was found to be associated with the formation defective microstructures with relatively large residual strain and high-density defects. In order to understand the mechanism behind the high coercivity of cobalt ferrites induced by mechanical milling, we examine the reversal magnetization processes based on both the micromagnetic model and the phenomenological model. Our study revealed that pinning-controlled mechanisms were responsible for the reversal magnetization processes of the CoFe$_2$O$_4$ sample with high coercivities. The pinning centers could be dislocation-typed defects, the highly-strained areas and grain boundaries with the formation of subgrains during the mechanical milling.

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ALL ARE WELCOME!